



## Westford I-Net Evaluation

May 13, 2002

**Description:** The Westford Institutional Network (I-Net) is configured as a high split CATV network. The amplifiers are C-Cor model LAN 101 units. The forward signal path has a bandwidth of 222 MHz to 450 MHz, the return path covers 5 MHz to 186 MHz. The forward and reverse signal paths terminate at the AT&T headend facility at 49 North Main Street in Graniteville.

Presently, there is one analog NTSC carrier on channel 8 that originates from the Westford Academy and is transported to the AT&T headend. The programming usually is the NASA channel, which is inserted onto the residential network on Channel 60.

The I-Net also supports a data network that utilizes Zenith cable modems. The modems are installed at the following locations: Westford Academy, Town Hall, Blanchard School, Day School, and the School Administrative Office. The modems use channel 3 on the reverse path and channel 29 on the forward path. The data connection through the modems is used to access the Internet, along with e-mail and file sharing. The data network's hub is located at the Blanchard School.

The I-Net also passes the Library, Rodenbush Center, Frost School, Abbott School, and the Nabnasset School. At this time, these facilities don't utilize the I-Net.

**Evaluation:** The week of April 15 was used to verify the design and balance of the I-Net, because it was a school vacation week. Each amplifier was aligned in the forward and reverse direction. Then each modem was set up for proper transmit and receive levels into the I-Net.

In the following weeks we did some proof of performance testing to validate the integrity of the I-Net. The forward and reverse path was tested for frequency response over the bands of interest. This was accomplished by injecting the output of a Wavetek sweep generator into the I-Net and receiving the signal at the other end on a Tektronix spectrum analyzer. The reverse plant showed a peak to valley of 5dB, while the forward plant showed a peak to valley of 8dB. This meets or exceeds the FCC requirements over the bands of interest.

Using the Vertical Interval Test Signals (VITS) imbedded in the NASA programming on Channel 8 from the Westford Academy, we made hum, frequency response, signal to

noise, and color tests. These tests showed the performance of the video signal from the NASA satellite uplink through the Academy's satellite receiver to the Channel 8 modulator and through the I-Net to the headend. The test equipment used was the Tektronix DS1001 Television Demodulator, Tektronix VN700A Video Measurement Set, and a 2715 Tektronix Spectrum Analyzer.

The hum measurement was made using the 2715 Spectrum Analyzer in the demodulator mode, observing the signal in the field rate mode. No measurable hum was observed.

The inband frequency response was made using the demodulator and VM700A video test set, utilizing the multiburst signal in the VITS of Channel 8. The frequency response measured + 0.83 dB to -3.48 dB, while this exceeds the FCC parameter of +2 to -2 dB subsequent tests at the Westford Academy showed the school owned satellite receiver displayed a frequency response of +0.65 dB to -2.03 dB.

Video signal to noise, again measured with the VM700A was 48.1 dB at the headend, and 49.3 dB out of the satellite receiver. This shows a 1.2 dB contribution from the I-Net.

The color parameters were also measured using NASA's VITS utilizing the modulated stair step for differential gain and phase, and the 12.5 T pulse for chrominance-luminance gain and delay. The differential gain was 6.3%, phase 2.0 Ø. Chrominance-luminance gain was 69% and the delay was 239 nanoseconds.

**Discussion:** While the FCC tests cover only the CATV part of the overall signal path, I was interested in the performance of the total link, as the NASA signal is subsequently delivered to our customers. The video and color parameters measured are impacted primarily by the video processing equipment at each end of the I-Net, not by the I-Net itself, with the exception of signal to noise (S/N).

While some of these parameters exceed the FCC CATV parameters, it must be understood that the FCC realizes that incoming signals are not perfect and the combined distortions will be worse. It is the CATV operator's job to keep his/her operating parameters such that the system will further impact the signal to a minimum degree as spelled out in the rules. The overall numbers still will result in good pictures to the customer. As we will show in the following tests, that by using quality video equipment at each end we can demonstrate that the I-Net is performing correctly.

**Forward signal tests:** Because there is no video signal on the forward signal path of the I-Net, we inserted one at the headend using the General Instruments C6M II modulator and the Tektronix 1910 video generator. We selected channel 25 for the tests. Tests were then run at the Westford Academy and Nabansett School.

At the Academy the following results were measured:

Inband frequency response: -0.49 dB to -1.0 dB. For a total of -0.51 dB.

Video signal to noise: 55.4 dB.

Differential gain: 1.3 %

Differential phase: 0.50Ø  
Chrominance-luminance gain: 88%  
Chrominance-luminance delay: 3.4 nanoseconds

At the Nabnasset School the following results were measured:  
Inband frequency response: -0.14 to -0.49 dB. For a total of -0.35dB.  
Video signal to noise: 55.7 dB.  
Differential gain: 1.6 %  
Differential phase: 0.53Ø  
Chrominance-luminance gain: 92.7 %  
Chrominance-luminance delay: 3.0 nanoseconds

These numbers are essentially the same as achieved when connecting the test equipment back to back on a bench.

No measurable hum was observed.

**DOCSIS compliance:** Because of the interest in deploying DOCSIS cable modems on the I-Net, we ran Bit Error Ratio (BER) tests in the forward and reverse directions on the I-Net. First, we set up a Radyne Quadrature Amplitude Modulation (QAM) modulator and a General Instruments C8-U up-converter at the headend and a HUKK Digital Analyzer at the Academy and let it run for 26 hours. The analyzer will display Modulation Error Ratio (MER), BER, and will record errored seconds over time.

The QAM modulator was set for 64 QAM and set for normal system operating Radio Frequency (RF) levels.

After operating for 26 hours the analyzer displayed an MER of 34 dB, no BER's and no errored seconds.

We then reversed the procedure and installed the QAM modulator at the Academy and recorded the results at the headend with the analyzer over a period of 22 hours. The MER was 34 dB, no BER's and 1 errored second.

**Discussion:** DOCSIS modems are usually operated at 64 QAM in the forward direction, and at 3.2 MHz. Quadrature Phase Shift Keying (QPSK) in the reverse direction. 64 QAM is a relatively fragile modulation scheme compared to QPSK modulation. QPSK was chosen to operate in the fairly hostile environment of the normal CATV system's reverse path because of its robustness.

Testing the forward and reverse path at 64 QAM has proven that the I-Net can support the DOCSIS platform. DOCSIS deployment on a CATV system is predicated on the assumption that the system meets FCC test parameters, which the Westford I-Net does. If the town decides to use the I-Net with DOCSIS modems, I would recommend redesigning the termination point from the AT&T headend to the Blanchard School to

better accomplish the installation of the Cable Modem Termination System (CTMS) bridge to the Internet.

*[Illustrations were deleted to save file space – Contact Westford CAC to see them.]*

### List of Test Equipment

Vendor	Model	Equipment	Serial Number
Tektronix	DS1001	Demodulator	GB 10111
Tektronix	VM700A	Video Measurement Test Set	B042823
Tektronix	1910	Digital Signal Generator	B023249
Tektronix	2715	Spectrum Analyzer	B030800
General Instruments	C6M II	Television Modulator	J6N7000665321
General Instruments	C8U-L	Channel Up-Converter	
Radyne	256 QAM	QAM Modulator	1200
Wavetek	1067	CATV Sweep	2330364
HUKK	CR1200R	Digital Signal Analyzer	B046000689

### Qualifications

Calvin B. Cole: Staff Engineer with AT&T Broadband, previously with MediaOne and Continental Cablevision. Thirty-two years in the industry, performing FCC Tests and qualifying CATV systems. FCC General Radio Telephone License number PG-1-8926.